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3,242,984

HEAT EXCHANGERS WITH REINFORCED FINS

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2 Sheets-Sheet 1

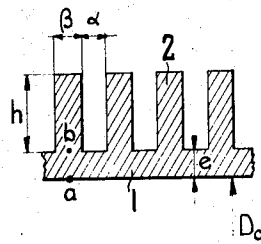


FIG. 1

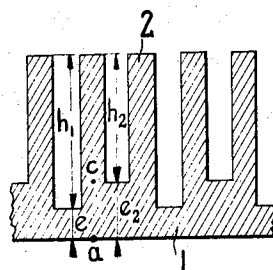


FIG. 2

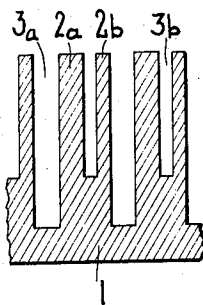


FIG. 3

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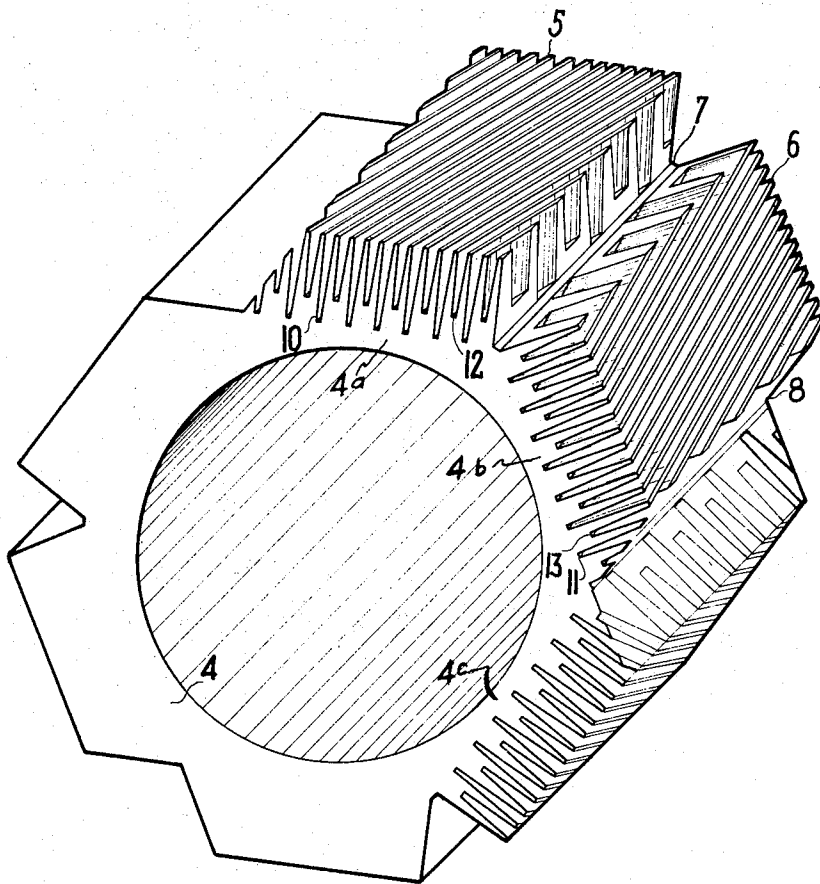
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FIG. 4



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HEAT EXCHANGERS WITH REINFORCED FINS
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5 Claims. (Cl. 165—185)

The present invention relates to heat exchangers, one face of which is disposed in contact with a source of heat, the other face being provided with cooling fins.

More particularly it relates to sheaths for fuel elements for nuclear reactors, the surfaces of which are provided with cooling fins distributed in any appropriate configuration and being provided with sub-channels for allowing a cooling fluid to flow, and acting as a heat exchanger.

The invention has for a principal object to provide such an exchanger that will better respond to the diverse exigencies of use than those hitherto used, and particularly by avoiding the risk of extrusion by a decrease in the bending moment and in the temperature at the base of the fins. Due to the decrease of the bending moment there may be used a metal possessing better neutronic qualities but having poorer mechanical characteristics. Due to the decrease in the temperature at the base of the fins the temperature of the sheath may be increased to obtain a better output from the reactor.

The invention consists principally in a heat exchanger located in a conduit for circulating a heat-transfer fluid provided on one of its faces with fins defining between them sub-channels throughout the depth of which the heat transfer fluid flows, said fins being of the longitudinal type and arranged in chevron, spiral polyzonal or transverse dispositions with induced flow, and wherein the said sub-channels are distributed regularly in successive similar groups, the depth and/or width of said sub-channels of a same group varying from one sub-channel to the next.

Certain other features may be present in the above arrangement, for example each group of sub-channels may be formed by two sub-channels. Moreover the fins may be of a rectangular or a trapezoidal section and may additionally have variable thickness. Moreover the base of the sub-channels may be flat, concave or convex.

In order that the invention may be more clearly understood, reference will now be made to the accompanying drawings which show some examples thereof in relation to previously made heat exchangers and in which:

FIGURE 1 shows an axial section along a heat exchanger of a conventional type,

FIGURE 2 is an axial section along a heat exchanger according to the invention in which the depth of the sub-channels is variable,

FIGURE 3 shows a similar axial section of a heat exchanger according to the invention in which the depth and the width of the sub-channels and the thickness of the fins are variable, and

FIGURE 4 shows an isometric projection of an embodiment of heat exchanger according to the invention applied to a sheath having fins arranged in a chevron pattern.

As will be seen from FIGURE 1 which is a section taken perpendicularly to the fins 2 which are at least locally parallel, the structure of an exchanger may be defined by a certain number of parameters which are the thickness e of the exchanger, the height h of the fins, the width α of the sub-channels, the thickness β of the fins, and the diameter $D\phi$ of the source of heat which in the example selected is a cylindrical tube of uranium.

According to the invention and as represented for example in FIGURE 2, a heat exchanger having reinforced

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fins may be such that from one fin to the next, the thickness of the exchanger varies. It may be defined by variable parameters which are the thickness e and the extra thickness e_2 of the heat exchanger, the height h_1 of the deeper sub-channel and the height h_2 of the shallower sub-channel.

It can be shown by calculation and taking into account experimental results which have been obtained, that there exists an infinity of exchanger profiles having reinforced fins according to the invention (FIGURE 2) whose performances (coefficient of thermal exchange and coefficient of loss of aerodynamic loading) are equal to those of the profiles of reference (FIGURE 1). The following relationship is arrived at for two profiles having the same width α of the sub-channels, the same thickness β of the fins and the same minimum thickness e of the exchanger:

$$\frac{h_1 + h_2}{2h} = \frac{2e + D\phi}{(e + e_2) + D\phi}$$

If these two profiles have the same performances, this indicates that under the same operating conditions in the reactor, in the example of a nuclear fuel element, the maximum temperature of a layer on the internal wall (at a) remains the same in the two cases.

The cooling of the sheath is characterised by a drop in the temperature across the actual thickness and along the fins, the point b being cooler than the point a . In an improved exchanger according to the invention and such as is shown in FIGURE 2 it will be found that not only is the point c cooler than the point a but also cooler than the point b . If the difference between the temperatures of the sheath and of the cooling gas is about 100°C . the difference between a and b is about 12°C . whilst that between a and c is in excess of 20°C . Thus, in an exchanger according to the invention the base of the fins is substantially cooler than in exchangers of types previously employed.

Example

An experimental study has been made on two sheaths according to the invention and similar to that shown in FIGURE 2, and having a value h_1 equal to 7 mm. and two values for h_2 respectively equal to 6.31 and 5.65 mm.

If the value of the maximum constraint in the profile of FIGURE 1 (point b) is taken to be unity, there is obtained for the two examples chosen according to FIGURE 2 constraints respectively of 0.87 and 0.64 (point c). If the value of the sag or depression attained by the fin in the more highly stressed zone, by extrusion in a given time in the profile of FIGURE 1, is also taken as unity, the sag or depression for the profiles according to FIGURE 2 will respectively be about 0.8 and 0.5 without moreover taking into account the decrease in temperature of the loaded zone (respectively of 10 and 20°C .), which operates equally in the direction of decrease in the extrusion. The decrease of this temperature which is very difficult to put into figures so far as the extrusion is concerned, allows above all two improvements to be obtained: on the one hand an increase in the temperature of the hot point of the sheath equivalent to the decrease obtained at the weakest part of the profile under consideration, and on the other hand an increase in the exchange coefficient by increase of the number of fins, the temperature of the loaded point being lower.

As will be seen from FIGURE 3 the fins may alternatively be wide ($2a$) and narrow ($2b$) and the channels alternatively wide and deep ($3a$) and narrow and less deep ($3b$).

This disposition is moreover in no way limitative and all kinds of dispositions are possible according to the invention, the bases of the sub-channels also being variable for example they may be flat for the less deep sub-

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channels, with a convex base for the deep sub-channels.

FIGURE 4 shows an embodiment of the sub-channels in accordance with the invention on a sheath or tubular member 4 of generally polygonal configuration as viewed in cross-section provided with fins arranged on the surface of the sectors 4a, 4b, 4c, etc. in a chevron pattern, alternately going in one direction and the other (fins 5 and 6 respectively) separated by passages such as 7 and 8 which are devoid of fins. The sub-channels provided between the fins are here according to the invention alternately deep (sub-channels 10 and 11) and less deep (sub-channels 12 and 13). The bottom wall of the sub-channels 10 in each sector may be considered as lying in the plane of the surface of the respective sector.

It will be understood from what has gone before that the invention is not limited to the method of application and to the embodiments described and represented, but on the contrary may include all modifications which fall within the spirit and scope of the invention as defined in the appended claims.

We claim:

1. A heat exchanger for location in a conduit in a nuclear reactor through which a heat transfer fluid is adapted to be circulated, comprising: a tubular member having a passage extending therethrough for receiving a nuclear fuel element therein, the outer surface of said member being of polygonal configuration as viewed in transverse cross-section and providing a plurality of identical sectors arranged therearound; and a plurality of fins formed integral with said member and extending outwardly substantially the same distance from the surface of each of said sectors; the fins being parallel to each other on each sector and inclined at an angle to the axis of said member and in opposite directions in adjacent sectors so as to form a chevron pattern, said fins in each of said sectors defining therebetween channels for the flow of said heat transfer fluid therethrough, the alternate channels in each of said sectors extending from the outer extremity of said fins to the surface of the sector being of a uniform, predetermined depth and the adjacent channels disposed between said alternate channels in each of said sectors being of a uniform depth different from said predetermined depth.

2. A heat exchanger as defined in claim 1 in which

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the alternate channels in each of said sectors are of substantially the same width and the adjacent channels are of a different width.

3. A heat exchanger as defined in claim 1 in which the extremities of each fin at the longitudinal edges of each sector extend substantially perpendicular to the surface of the respective sector, the extremities of the fins of adjacent sectors providing flow passages for said heat transfer fluid extending longitudinally of said member and between adjacent sectors.

4. A heat exchanger as claimed in claim 1, in which the alternate fins in each of said sectors are of substantially the same thickness and the adjacent fins are of a different thickness.

5. A heat exchanger as defined in claim 4 in which the alternate channels in each of said sectors are of substantially the same width and the adjacent channels are of a different width.

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